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The digital reconstruction of hiking trail system evolution in the Mátra Mts, Hungary

Keywords: hiking maps, hiking trails, tourism, Leaflet

Summary: The Mátra Mts has been one of the most frequented tourist destinations in Hungary for over a century. Famous wine regions, thermal waters, rich cultural heritage, and high natural diversity attract tourist even from other countries. Being the highest mountain range in Hungary, it has been popular among people who prefer winter sports and various natural activities. Because of these, the mapping of hiking and tourism infrastructure have begun relatively early: there are guidebooks with suggested tours and tourist/hiking maps even from the end of the 19th century. The purpose of our study was to analyse and reconstruct the hiking trail system evolution of the Mátra Mts. We have collected (from online sources and libraries) and scanned the accessible hiking maps of the area. The first processed data source is from the end of the 1920s. We have georeferenced the maps and digitized the marked hiking trails from all available base material: we got a large database incorporating more than a 100 years history of our sample area (from more than 50 sources). A Leaflet-based webpage has been developed to interactively present the evolution of hiking routes. Visitors can follow the changes from year to year (from data source to data source) with the help of a timeline regarding every different trail sign. This work has a large significance in the tourism history of the area: all historic data are browsable using one webpage. Besides, it is a good base material to further analyse the development of tourism infrastructure and changes in hiking habits.

Introduction

Hiking has been an important recreational activity for a long time. People usually prefer areas and landscapes with large natural and cultural diversity: these ensure multiple choices when planning free-time programmes. The Mátra Mountains is one of the most frequented hiking places in Hungary due to its notable historical and geographical properties.

Since the beginning of tourism development (the second half of the 19th century), it has been popular mainly among Hungarians because of its winter sports opportunities and natural environment. Nowadays a lot of people travel here both from Hungary and across the border as new attractive elements appeared like wine tourism, renewed cultural sites, and even extreme sports facilities.

Because of this infrastructural development, we decided to analyse the evolution of the hiking trail system around the Mátra as a factor that improved with the growing number of hikers. We collected and digitized maps from several sources to create an interactive geodatabase. Among local importance, these data can form the basis of various tourism, cultural and natural research projects.

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Our sample area: the Mátra Mountains

The Mátra is the highest mountain region in Hungary, a part of the North Hungarian Range between the Cserhát and the Bükk regions. Its highest peak is Kékes (1014 m). Its extent in the E-W direction is 40-50 km and, in the N-S direction is 15-22 km. Tourism and hiking activities are in close relations with natural and socio-economic factors that root from the mountainous characteristics of the area. The overview map of the Mátra (Fig. 1) presents the surroundings and the main roads in the area that make the region accessible.



Figure 1: The surroundings of the Mátra Mts

Natural environmental setting

The Mátra Mts is a part of the inner volcanic arc of the Carpathian Mountain Range. Therefore, the main part of the mountain is built up by Middle Miocene (Badenian) pyroxene-andesite, tuffs, and agglomerates (16.5–13 M years). The root of the volcanism was the interaction between the AL-CAPA and the Tisza Plates. Around the volcanic formations (in the Mátraalja and Mátralába – lower altitudes) limestones, marl, and clay sediments characterize the area (Budai & Konrád 2011, Dövényi 2012).

The morphometry of volcanic forms is a great tourist attraction and a current scientific topic for geomorphologists. The northern slopes are steep with debris flows and landslides. The southern part of the mountain is less steep with long stream valleys and gentle slopes (Karátson 1997). Scientists debate about the potential calderas and other types of volcanic forms. According to the latest results, the andesite formation is connected to local eruption centres, and the main bordering valleys and other geomorphological elements were mainly formed by tectonic movements (Hartai 2005). Some post-volcanic activities make the region interesting for tourists: the sulfuric-carbonated springs of Paráds and Recsk and the fumaroles (sulphuric gas-emitting ground openings) of Mátrarecske.

The climate is temperate mountain with regular zonality having differences between northern and southern slopes. The highest part has a 5-8°C average temperature with 700-900 mm precipitation. The cool-wet northern Mátralába has an 8°C average temperature with 600-700 mm precipitation while the temperate warm-temperate dry Mátraalja (southern part) has 9-10°C average temperature and 550-700 mm precipitation.

The higher altitudes have brown soils with beech forests. As we go lower, chernozem-brown soils are common with oaks and hornbeams. The Mátraalja is famous for its wines (Fig. 2): it is the area of the Mátra Wine Region (Karátson 1997).



Figure 2: The southern part of the Mátra: the lower parts are planted with grapes as these slopes are rich in sunlight

Socio-economic effects

The Mátra Mts and its surrounding give home to people since ancient times: many tools of early mankind can be found in the Mátra Museum. There are remnants of castles and ramparts from the Bronze Age (Benevár, Vár Hill of Paráds and Jobbágyi, Hajnács Stone). Some of these were rebuilt in the Middle Ages (Ágasvár, Castle of Markaz, Oroszlánvár [Lion's Castle], Castle of Sirok). These ancient ruins and renewed castles are great tourist attractions.

The Franciscan Monastery of Gyöngyös has a rich collection of codex and ancient printings that were preserved even during the Turkish occupation. After the revolution of 1848-49, the woods of the Mátra became home for hidlers and ‘betyárs’ (outlaws or rogues). The most famous is Márton Vidróczki, who often appeared in arts and literature. Even the famous composer Zoltán Kodály wrote about him in his ‘Pictures of the Mátra’ piece.

The historic inhabitants of the Mátra and its surroundings belong to the ethnographic group of the Palóc people whose origins are disputed. Their dialect, building style, traditional costume and cuisine is special even in Hungary. The other group of people – Moravian, Czechian and Slovakian groups – settled here since the end of the 18th century. They moved to higher altitudes founding new villages and starting new industries: glassmaking, producing charcoal and founding asheries. The names of these new villages originate from the glassmaking activity: the suffix ‘huta’ of the old village names relate to glass manufactures (Szuhahuta, Fiskalitáshuta, Ötházhuta, Felsőhuta). Forestry has been another important economic sector since the Middle Ages. The production of building materials, tools and firewood demanded large tree cutting activity that also freed areas for grazing. Because of this, soil erosion, degradation was common before the forest law of 1879 when forest management got its specific laws. At the beginning of the 20th century, pine woods were planted in large areas. After the closing of asheries, hunting became the main activity in the mountains. The socialization of the woodlands after the end of the II. World War brought planned deforestation that was reorganized later. Hunting remained an important use opportunity of the forests that also has positive economic effects due to hunting tourism (Kovács & Horváth 2017).

The past and present of tourism in the Mátra Mts

Many famous sights preserve the results of the hard-working people who struggled for the foundation of tourism in the Mátra. The Hungarian Carpathian Association’s Mátra Department was responsible for the tourism infrastructure of the Mátra Mts from 1887 led by Kolos Hanák and István Széky. They built tourist shelters, guest houses and lookout towers on the route between Galya-Kékes-Bene. The establishment of the first marked hiking trail in 1888 is also connected to them (red line in the Kalló Valley). The first tourist guide of the Mátra was published by Kolos Hanák (1897). The building of the railway on the northern side of the mountain and the car road from Parádszék to Gyöngyös in 1907 led to a great development regarding the number of tourists. After the I. World War, the Mátra became the highest mountain area in Hungary. Many new facilities were established (e.g. the House of Mátra, the ‘Pagoda’) and luxurious hotels were built. Shortly before the II. World War, many tourists started to explore the ‘huta’ villages between Galya and Pásztó. After 1945, almost every tourist facility was socialized. The large wave of constructions and tourist guide publishing (e.g. Sport Press issued many guides) have ended by the middle 1970s, the continuity of development broke.

After the regime change of 1989-90, the hotels, resorts and other facilities were privatized and started to renew slowly. Nowadays the tourism of the Mátra is built on two basic pillars: the special ethnographical and industrial past (forestry and glassmaking) and the spectacular natural environment. New hiking routes were marked, and hotels were built and the Mátra started to catch up on the other parts of the country in tourism development. The most important resorts are Mátrafüred, Sástó, Mátraháza, Kékestető, Galyatető and Mátrászentimre. Nearly every sight can be reached on hiking trails. Castles (e.g. the Károlyi Castle in Parádszék), small churches (e.g. the Church of the Three Villages in Mátrászentimre and the pilgrimage site of Fallóskút) and the museums of

Gyöngyös (e.g. the Mátra Museum and the Franciscan Monastery) preserve the rich cultural heritage. The narrow-gauge railway network mixes the beauty of nature with industrial history (as these railways were used for forestry and mining purposes originally). Winter sport facilities can also be found in Kékestető and Mátrszentistván (Kovács & Horváth 2017).

A brief history of Hungarian hiking maps

The aim of tourist and hiking maps to present the most picturesque and naturally-culturally interesting landscapes to the tourists. These cartographic products help them to orientate in the field and to find various sights. A hiking map is traditionally made with the generalization and thematic completion of topographic maps (the simplification is dependent on the desired scale). The visualization of contour lines, vegetation, road network, trails, manmade objects, and tourism infrastructure demands large-scale visualization: therefore, the ideal scale of hiking maps is between 1:20 000 and 1:50 000 (Klinghammer–Papp-Váry 1983).

The first map for tourism purposes was made by Miklós Szerelmey (1848) and was published in his Balaton album: its purpose was to present the beautiful landscape and sights for steamship travellers. The Hungarian Carpathian Association (Magyarországi Kárpát Egyesület) and the Hungarian Tourist Alliance (Magyar Turista Egyesület) issued a few tourist maps and guides: the Tatra Mountains in 1876, Budapest in 1899 and the tourist guide of the Mátra in 1897. The first map presenting the detailed hiking trails of the Pilis Mountains was issued in 1890 (Klinghammer–Papp-Váry 1983). Printing trail networks on military maps were common these times: it was a cheap and fast solution, but these topographic maps were in German and became outdated soon (Irmédi-Molnár 1967).

The Royal Hungarian State Mapping Institute was established in 1922 and soon started to issue a new series of hiking maps (Strömpl 1931). The name of the map series was ‘Hikers’ map’, but these were usually referred to as ‘maps with the angels’ because of their front cover. The Buda Mountains was the first in 1928 that was followed by the other mountain and hill ranges of Hungary. The Mátra map was issued in 1933 that was processed in this study (Fig. 3). The visualization was simplified compared to the topographic maps, but these were exact, visually satisfying and meant a blooming era of Hungarian hiking tourism between the world wars.



Figure 3: The front and back cover and an excerpt (around Mátrafüred and Markaz) of the 1933 'Hikers' map' of the Mátra Mts

After the end of the II. World War, the quality and exactness of hiking maps declined. The military restrictions of the Cold War period forced cartographers to make less informative and exact maps. Kartográfiai Vállalat was founded in 1954 and was in a monopoly position regarding civil mapping, so the production of hiking maps too. Until the 1960s these maps were drawn with certain distortions: angular railways, lack of contour lines and the scale number was also omitted sometimes.

The scale of some maps was too small for walking (e.g. Bakony, 1:80 000). No coordinate or projection information was drawn on the maps, so they were hardly available for exact field orientation (Klinghammer–Papp–Váry 1983, Fig. 4). Since the 1950s tourist guides were issued that were the predecessors of the tourist guides and atlases of the recent years (Kovács & Horváth 2017).

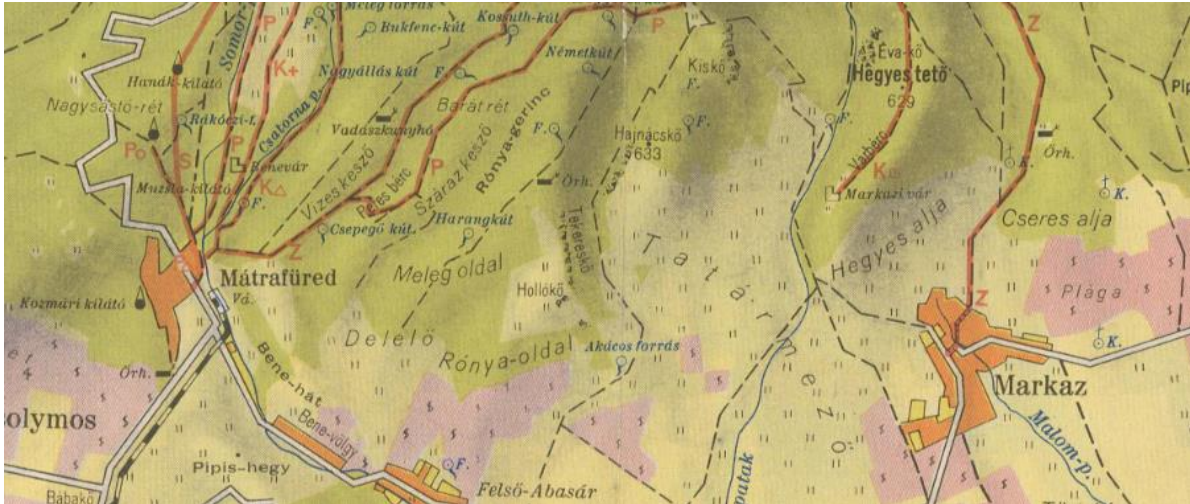


Figure 4: A hiking map excerpt from 1956: no contour lines or coordinate grid are drawn; line features are angular and many other details are omitted

The hiking maps have significantly improved from the end of the 1970s. Most of them got at least a kilometre grid that made route planning easier. Later geographic coordinates also appeared on maps. After the regime change in 1989/90, the monopoly situation of Kartográfiai Vállalat vanished. Many private cartographic companies were formed and started the making of tourist and hiking maps (e.g. Szarvas Térkép, Dimap, or Nyír-karta, Fig. 5). The successor of Kartográfiai Vállalat is called Cartographia. Despite the large number of private firms, it remained the most-known cartographic company in Hungary.

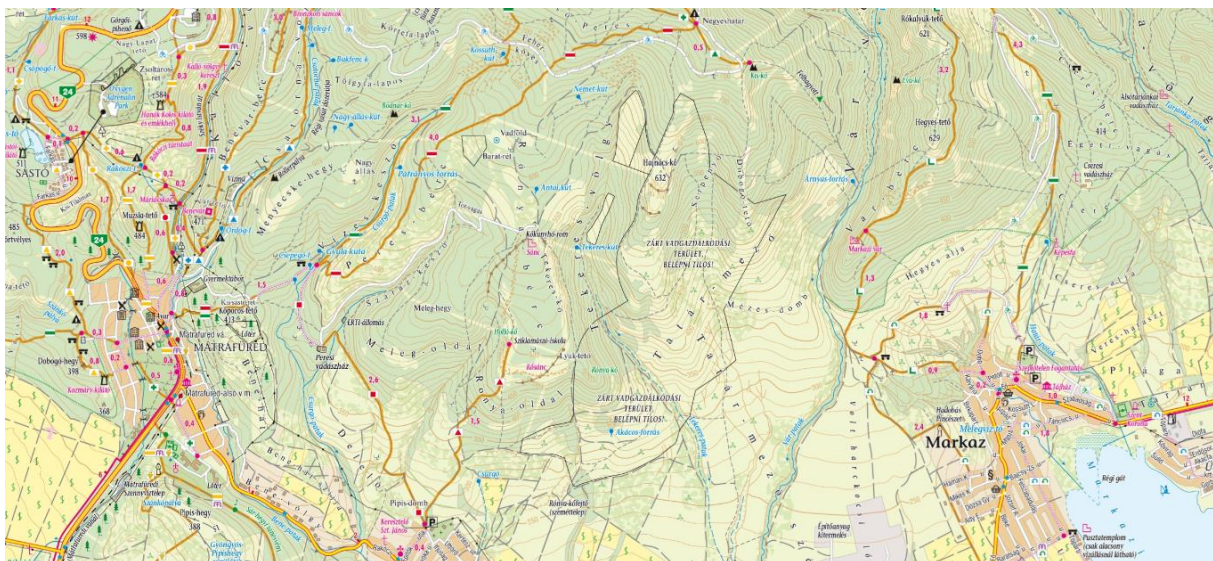


Figure 5: A 2018 hiking map excerpt edited by András Szarvas. It is much more detailed than the one in Fig. 4.

However, paper-based analogue map products started to take a back seat with the emergence of smartphones and digital maps. Numerous solutions make it possible to read maps and orientate, plan, or track our hike with the help of online or offline mobile applications. But hikers, especially the more experienced ones, stick to their well-known paper-based field friend.

The system of Hungarian hiking trail signs

Hiking is one of the most popular outdoor activities in Hungary. The number of hiking trails has increased in parallel with tourism infrastructure development and the need for natural recreational opportunities. The signs, that we use today to mark trails, appeared in 1929 (Strömpl 1929). These are organized in a hierarchical system of 4 colours (blue, red, yellow, and green) and various shapes placed in a white rectangle (Fig. 6). Their combination means the purpose and destination of the route (Molnár 2016).

a)  hiking trail of national significance  hiking trail of regional significance  hiking trail of local significance  hiking trail of local significance	b)  main hiking trail  cross - longer or shorter alternative of main hiking trail  square - tourist accomodation or settlements  circle - drinking water  triangle - hilltops or lookout points  omega - cave  ruin  circular hiking trail  educational routes - biological and earth scientific formations
c)  Mary's Way  Yellow Grapes  Mátrabérc Trail	

Figure 6: Hiking trail signs in Hungary and the Mátra Mountains: a) the hierarchical system of coloured line signs, b) routes categorized by their destination, c) thematic trails in the Mátra Mts

The most important trails are marked by coloured lines (Fig. 6a). The blue line is on the top of the hierarchy: these routes usually pass-through multiple regions (e.g. the 123 km long Metallurgists' Trail between Salgótarján and Miskolc) or even the whole country (the National Blue Trail – Országos Kéktúra). The 3 most important blue routes (the National Blue Trail, the Great Plain Blue Trail, and the Pál Rockenbauer South Transdanubia Blue Trail) form a 2579 km long continuous circle leading the hiker all around Hungary (MTSZ 2020). Trails marked by red lines are shorter than blue ones and usually lead through a few regions, mountain ranges and landscapes (e.g. Parád-sasvár–Mátrafüred through the Mátra). The yellow and green lines mainly mark trails with local significance. These are the shortest line-marked routes (Molnár 2016).

Furthermore, there are some different shapes among the line that marks a specific destination that can be reached following the trail (Fig. 6b). These sub-routes are branches of the main system built up by the line marks. These are also present in all 4 colours (derived from the line mark that it branches from) and every sign has an individual meaning. Cross-marked routes connect main trails or offer another alternative to line-marked ones. We use the square to mark the short branches leading to tourist accommodation or settlements. Short roads to springs, wells, and other drinking water sources are marked by a circle. Triangle-marked trails lead to hilltops, peaks, or lookout points. The omega letter is similar to a cave entrance – these routes lead to caves. The road sign to ruins, monuments, excavation sites is like an L letter. Circular hiking trails are marked by an arrow that returns to itself. These are suitable for shorter hiking; they return to the starting point without changing signs. The T-marked trails are mainly short educational routes connected to various biological or earth scientific phenomena and formations (Molnár 2016).

Among these shapes, there are some special symbols too, such as pilgrimage trails and thematic routes (Fig. 6c). On the tourist maps of the Mátra, there is a purple M-like symbol. This marks the Central European Mary's Route, which connects the shrines of Mary with the historical and cultural values along the trail between Mariazell (Austria) and Csíksomlyó (Șumuleu Ciuc, Romania). The pilgrimage site of Fallóskút in the Mátra is an important site of this route (Mária Út Egyesület 2021). There are other pilgrimage routes connecting sites in Hungary and other parts of Europe (e.g. the route of St. Martin from Szombathely to Tours, or the route of St. Elizabeth between Sáropatak and Košice). The yellow grape sign marks the latest hiking trail in the Mátra area. It is a 7-kilometre hike from Gyöngyös to Mátrafüred giving home for wine tours as wine gastronomy is very popular in this area. A special sign of the Mátra is a blue M. This is the Mátrabérc Trail. It leads on the main ridges of the Mátra in an East-West direction, 99% on forest roads. It is extreme due to the large vertical differences that are rare in Hungary to this extent. This is one of the most special natural backbone routes in Hungary with a length of 55 kilometres reaching the highest peaks of the mountains.

Processing hiking map data

The first step was to look for maps in the Map Library of the ELTE Eötvös Loránd University, Institute of Cartography and Geoinformatics. We found several analogue hiking maps of the Mátra Mountains from the 1970s to 2015 but not from every year. The maps for the missing years were gathered from two main distinct data sources. We have been provided with maps from the 20th century from the National Széchényi Library in digital form (mainly edited by the Kartográfiai Vállalat, but there were private issues and a few before the II. World War edited by the Royal Hungarian Military Mapping Institute). András Szarvas, a Hungarian private map publisher also made available his most recent Mátra hiking maps in a georeferenced version. We have collected about 53 from 1929 to 2019.

Table 1. Hiking map data sources

Data source	Time interval	Pieces	Format
National Széchényi Library	1929-2015	25	scanned hiking maps
Map Library of the ELTE Eötvös Loránd University, Institute of Cartography and Geoinformatics	1970-2015	25	analogue hiking maps
András Szarvas	2016-2019	3	georeferenced PDF

Fortunately, most of the maps have already arrived as scanned raster images and a relatively small subset of them were paper maps – we scanned these properly. However, just a few of them were georeferenced. Therefore, we had to georeference and pre-process most maps for working in a GIS environment. Some (mainly recent) maps could be georeferenced easily as geographical coordinates are present on them. But maps from the socialist era of Hungary (before 1990) did not give proper information on projection or coordinates. Sometimes just a grid of kilometres was put on them to make route planning easier (e.g. Kartográfiai Vállalat 1981), but it was also omitted earlier (e.g. Kartográfiai Vállalat 1977). By having a properly georeferenced map (based on geographic coordinates) many ground control points (GCPs) were marked that helped to process maps without coordinates. We mainly considered road junctions, mountain peaks or bridges as GCPs as the position of these points is rather fixed. An average number of 320 GCPs were marked in this work phase for every map. The map sources and the initial data formats are summarized in Table 1.

The set of georeferenced maps were compared to OpenStreetMap and other online map providers to check the exactness of georeferencing. Even though we added more than 320 ground control points, the differences between the layers were up to 50 meters.

The next step was to digitize the hiking trail network of the Mátra Mts and form a geodatabase. To make visualization more legible and clearer, the routes were not completely digitized. We downloaded the up to date Mátra tourist road network with the help of the Overpass API (<http://overpass-turbo.eu>). The trail database of each georeferenced hiking map was built up by this downloaded vector framework: if a line element existed, an attribute was assigned to it (from a raster map) that referred to the corresponding hiking trail sign (e.g. “kk” [kék kereszt] means blue cross or “ph” [piros háromszög] means red triangle in Hungarian). If a trail did not exist in the OSM database, we drew the line object and assigned the related trail sign attribute. However, the trail network was more and more different when we got back in time. While the 2019 map had nearly the same network as OSM and needed only minor work on the downloaded dataset, the trails on the 1929 map usually went on other paths and needed major digitizing. In this way, every georeferenced raster (TIFF) hiking map got its own vector hiking trail dataset that can be easily related to any OSM-related online base map. The initial geopackage (GPKG) formatted files were converted to GeoJSON – as this format can be handled easily when using Leaflet.

The Leaflet-based online map

To visualize the evolution and the changes in the hiking trail network we created a website using Leaflet. The Leaflet is an open-source JavaScript library that handles GIS data in a web environment. This website is mobile-friendly too, which is essential in the world of smartphones. Its well-

constructed manual and a large amount of online-shared user experiences and solutions make it easy to use (Leaflet 2021).

The construction of the webpage

The frame of the website is a combination of HTML (HyperText Markup Language) and CSS (Cascading Style Sheets). These give the basis of the website's structure: the main elements and the styles. We used JavaScript and its Leaflet library for visualizing map data on the webpage: the base maps, the hiking trails and the event handlers that provide interaction for HTML elements.

The functionalities of the webpage

Our online map is available at: [https:// http://mercator.elte.hu/~edina/matra/](https://http://mercator.elte.hu/~edina/matra/). When we open the website (Fig. 7), a default setting shows all the trails in 1929. The middle map part is the main element where the layers and the base maps are visualized.

Below the map, there is a slider with a small hiker on it. We can use this small figure to set the year to examine the trails existing in it. The first year is 1929 (the default setting) and the last one is 2019. As we change the year, the content on the map changes.

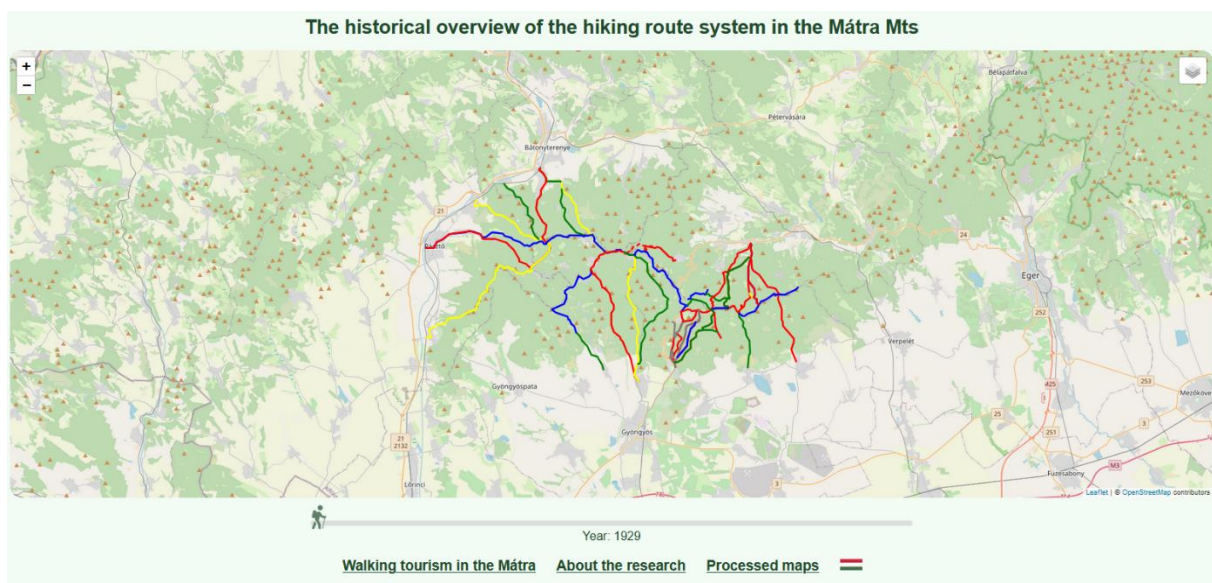


Figure 7: The default setting when a user opens the website

We can change the hiking trail data displayed on the map with another filter. There is a layer selector icon in the upper right corner of the map (Fig. 8). Here we can choose from two base maps and the thematic layers of the hiking trails. The first option shows every hiking route from the database for each year. If we do not want to see all of them, we can select the specific ones from the list that we are interested in. Multiple routes can be visualized at the same time.



Figure 8: Layer selector

Each signal that is listed in the layer selector can be observed each year. We can also look at the sign of each road on the map by clicking on the corresponding route. The sign of the route appears above it (Fig. 9).

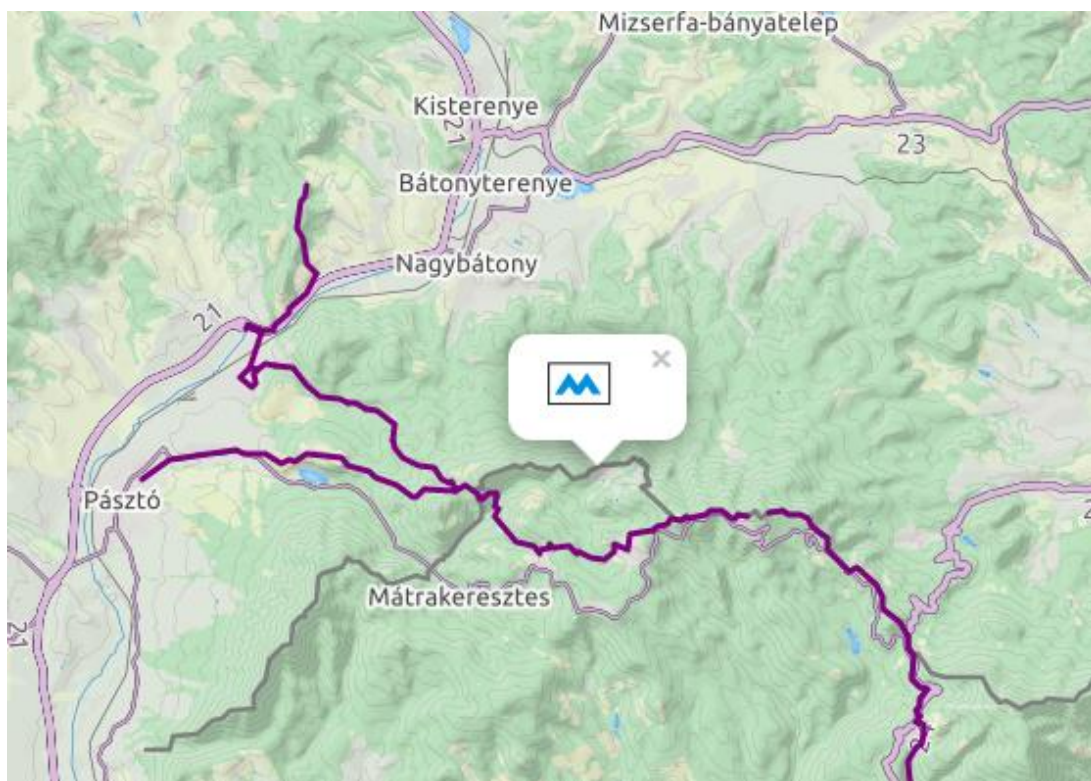


Figure 9: Hiking route sign (Mátrabérc) on the map

We can also examine all routes at the same time. This illustrates significantly the density change of hiking routes as the years change on the slider (Fig. 10).

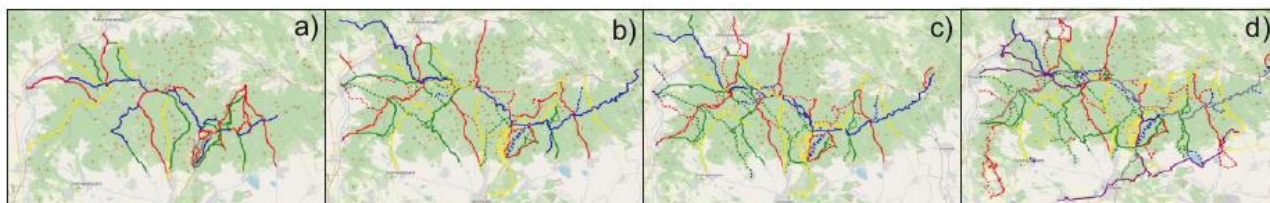


Figure 10: Changes in the density of the hiking route system over the years:
a) 1929, b) 1980, c) 2000, d) 2019

Conclusions and discussion

The digital preservation of cartographic data is a hard task, but it is essential for having an opportunity to find spatial information that is relevant for a certain period. We have processed nearly a 100-year history of the tourism of the Mátra Mts by forming this geodatabase and visualizing spatial data.

This enhances further research activities about the tourism of the Mátra: digital hiking trail data are available without having the corresponding (sometimes old) paper maps. Popular tourist destinations, natural resources and other geographic changes can be derived using our solution.

The visualized data support that the Mátra was already a popular area among tourists since the end of the 19th century. We can also determine how smaller areas (e.g. villages, resorts or natural features) became known: the appearance of hiking routes leading there indicates this. From this, we can determine when the tourism utilisation of the given area started.

The research, the geodatabase and the website give great value to the local people as their past and present are visualized and preserved. Furthermore, this project can encourage tourists from Hungary and abroad to visit the area.

Acknowledgements

We thank the National Széchényi Library, the Map Library of our Institute and András Szarvas for providing base materials and Prof. László Zentai for the help in data collection.

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